Course Code: BECE2012 Course Name: Electromagnetic Field Theory

UNIT 1

Coordinate Systems and Transformation

Lecturer-2

Course Code: BECE2012 Course Name: Electromagnetic Field Theory

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Vector Addition

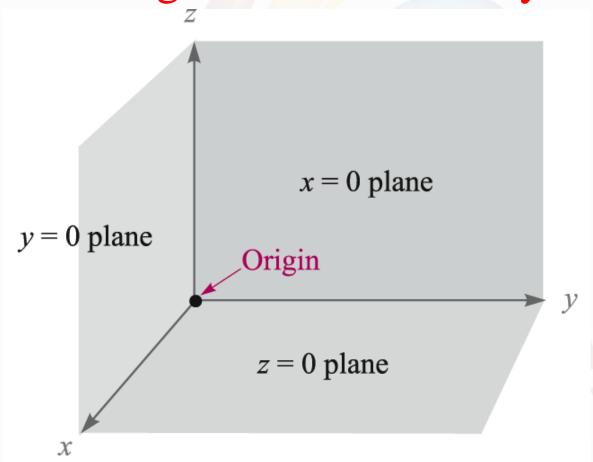


Associative Law:
$$\mathbf{A} + (\mathbf{B} + \mathbf{C}) = (\mathbf{A} + \mathbf{B}) + \mathbf{C}$$

Distributive Law:
$$(r + s)(\mathbf{A} + \mathbf{B}) = r(\mathbf{A} + \mathbf{B}) + s(\mathbf{A} + \mathbf{B})$$

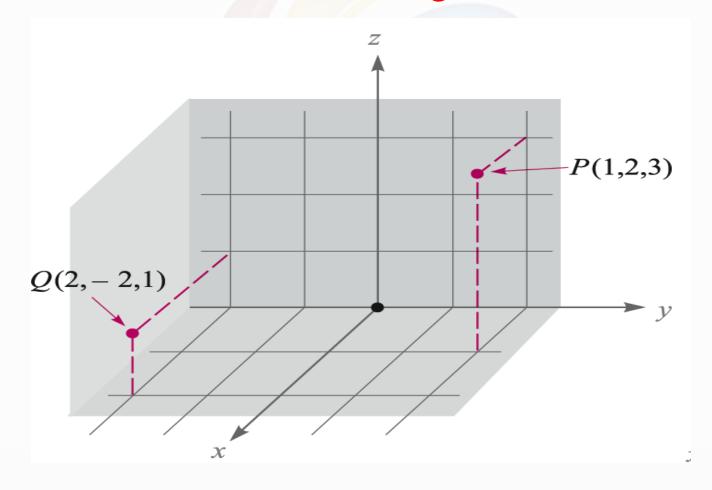
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Rectangular Coordinate System



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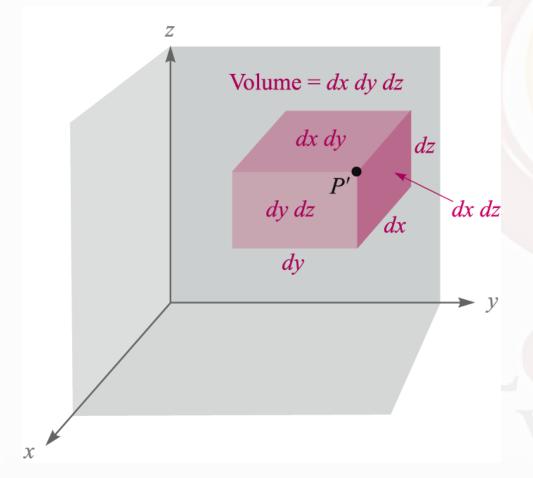
Point Locations in Rectangular Coordinates



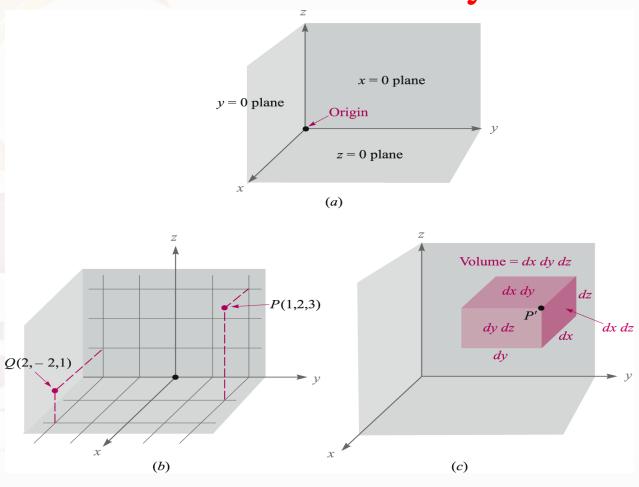
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Differential Volume Element

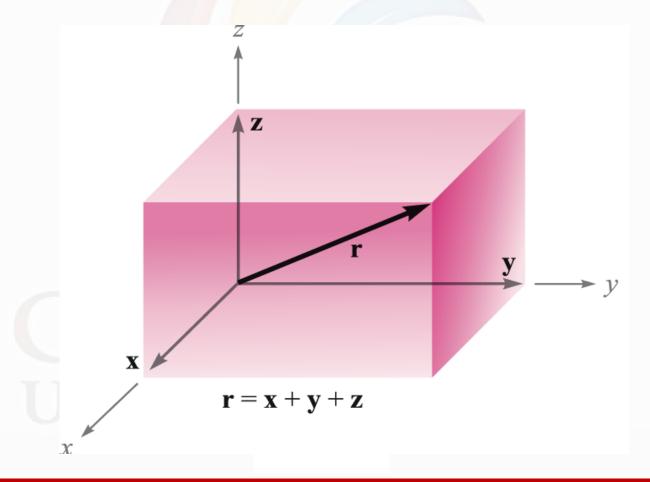


Summary



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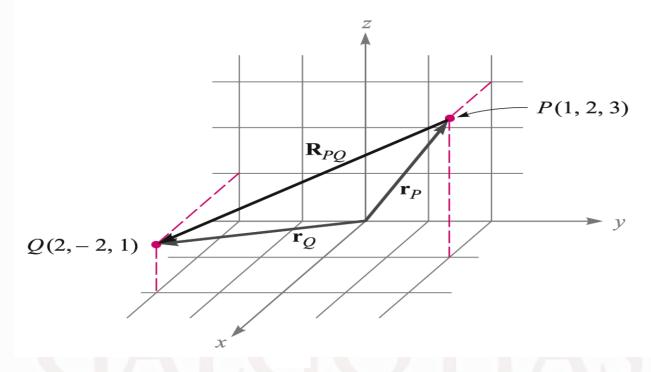
Orthogonal Vector Components



Name of the Faculty: Dr. Rohit Tripathi

Course Code: BECE2012 Course Name: Electromagnetic Field Theory

Vector Representation in Terms of Orthogonal Rectangular



$$\mathbf{R}_{PQ} = \mathbf{r}_Q - \mathbf{r}_P = (2-1)\mathbf{a}_x + (-2-2)\mathbf{a}_y + (1-3)\mathbf{a}_z$$
$$= \mathbf{a}_x - 4\mathbf{a}_y - 2\mathbf{a}_z$$

Name of the Faculty: Dr. Rohit Tripathi

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Vector Expressions in Rectangular Coordinates

General Vector, **B**:

$$\mathbf{B} = B_x \mathbf{a}_x + B_y \mathbf{a}_y + B_z \mathbf{a}_z$$

Magnitude of **B**:
$$|{\bf B}| = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

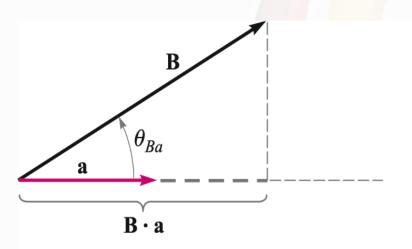
Unit Vector in the Direction of **B**:

$$\mathbf{a}_B = \frac{\mathbf{B}}{\sqrt{B_x^2 + B_y^2 + B_z^2}} = \frac{\mathbf{B}}{|\mathbf{B}|}$$

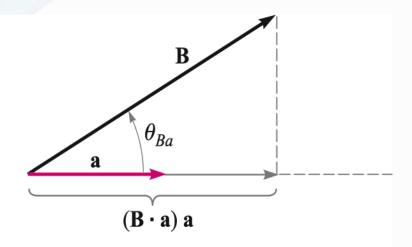
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Vector Projections Using the Dot Product



B • a gives the component of **B** in the horizontal direction



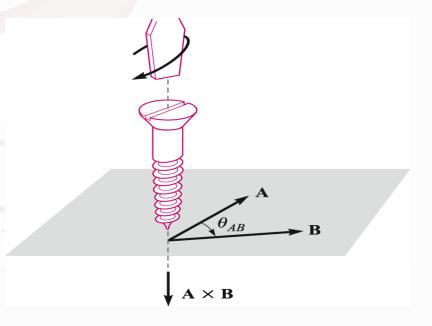
(**B** • a)a gives the *vector* component of **B** in the horizontal direction

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Cross Product

The cross product $\mathbf{A} \times \mathbf{B}$ is a vector; the magnitude of $\mathbf{A} \times \mathbf{B}$ is equal to the product of the magnitudes of \mathbf{A} , \mathbf{B} , and the sine of the smaller angle between \mathbf{A} and \mathbf{B} ; the direction of $\mathbf{A} \times \mathbf{B}$ is perpendicular to the plane containing \mathbf{A} and \mathbf{B} and is along that one of the two possible perpendiculars which is in the direction of advance of a right-handed screw as \mathbf{A} is turned into \mathbf{B} .

$$\mathbf{A} \times \mathbf{B} = \mathbf{a}_N |\mathbf{A}| |\mathbf{B}| \sin \theta_{AB}$$



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Operational Definition of the Cross Product in Rectangular Coordinates

Begin with:
$$\mathbf{A} \times \mathbf{B} = A_x B_x \mathbf{a}_x \times \mathbf{a}_x + A_x B_y \mathbf{a}_x \times \mathbf{a}_y + A_x B_z \mathbf{a}_x \times \mathbf{a}_z + A_y B_x \mathbf{a}_y \times \mathbf{a}_x + A_y B_y \mathbf{a}_y \times \mathbf{a}_y + A_y B_z \mathbf{a}_y \times \mathbf{a}_z + A_z B_x \mathbf{a}_z \times \mathbf{a}_x + A_z B_y \mathbf{a}_z \times \mathbf{a}_y + A_z B_z \mathbf{a}_z \times \mathbf{a}_z + A_z B_z \mathbf{a}_z \times \mathbf{a}_z$$

where
$$\begin{cases} \mathbf{a}_x \times \mathbf{a}_y = \mathbf{a}_z \\ \mathbf{a}_y \times \mathbf{a}_z = \mathbf{a}_x \\ \mathbf{a}_z \times \mathbf{a}_x = \mathbf{a}_y \end{cases}$$

Therefore:

$$\mathbf{A} \times \mathbf{B} = (A_y B_z - A_z B_y) \mathbf{a}_x + (A_z B_x - A_x B_z) \mathbf{a}_y + (A_x B_y - A_y B_x) \mathbf{a}_z$$

Or...
$$\mathbf{A} \times \mathbf{B} = \begin{vmatrix} \mathbf{a}_x & \mathbf{a}_y & \mathbf{a}_z \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

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References

- 1. H. Hayt and J. A. Buck, "Electromagnetic field theory", 7th Edition, TATA Mc Graw Hill.
- 2. M. N. O. Sadiku, "Elements of Electromagnetics", 5th Edition, Oxford University Press 2010

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